Ambient Groundwater Quality of the Yuma Basin:

A 1995 Baseline Study

Prepared by

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September 1998
OFR 98-7

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ADEQ OFR 98-7
September 1998

ABSTRACT

The Groundwater Monitoring Unit of the Arizona Department of Environmental Quality (ADEQ) conducted a baseline groundwater quality study of the Yuma Groundwater Basin (YGB) in 1995. Fifty-five wells were sampled for Safe Drinking Water (SDW) inorganics, with a lesser number of samples collected for the banned-pesticides DBCP and EDB (41 samples), Groundwater Protection List pesticides (21 samples), and radionuclides (7 samples). A stratified random sampling design was used to select 42 wells that are equally distributed in three physiographic areas (Gila Valley, Yuma Mesa, and Yuma Valley) and two groundwater zones (upper, fine-grained and lower, coarse-gravel). Also sampled were 13 wells targeted around land uses and/or an area of high nitrate levels.

Laboratory results revealed no detection of any pesticides. Of the inorganic and radionuclide parameters with health-based Primary Maximum Contaminant Levels (MCLs), only nitrate exceeded the water quality standard in five wells - four of which are located in the eastern South Gila Valley. In this area of high nitrate levels, one nitrate sample exceeded the Primary MCL by a factor of twelve. Of inorganic parameters with aesthetics-based Secondary MCLs, chloride, iron, manganese, sulfate, and total dissolved solids frequently exceeded water quality standards. This data suggests that regional groundwater quality conditions in the YGB generally support drinking water uses but because of aesthetic factors, residents may prefer to use treated water for some domestic purposes.

YGB groundwater has no dominant water chemistry and is chemically fairly uniform and similar to Colorado River water. Many groundwater quality parameter levels are positively correlated with one another which may indicate a common source of salts and minerals. These findings support the assertion made by previous studies (Olmstead and others, 1973) that groundwater in the YGB consists largely of recharged Colorado River water.

Statistical analyses comparing the upper, fine-grained and lower, coarse-gravel groundwater zones indicate no significant differences exist between groundwater quality parameter levels; however, when groundwater quality parameter levels are compared with groundwater depth below land surface (bls), many parameters have decreasing levels significantly related to increasing groundwater depth bls. Numerous statistically-significant differences exist in groundwater quality parameter levels among physiographic areas, with many inorganic parameters having higher levels in Gila Valley than Yuma Mesa and Yuma Valley. These spatial groundwater quality differences may be due to unique histories involving how long an area has been irrigated, depth to groundwater, and - especially - the source of irrigation water. The irrigation source in Gila Valley has predominately been groundwater with this resource being constantly recycled and degraded; in contrast, “fresher” Colorado River water has been chiefly applied for agriculture in the Yuma Mesa and Yuma Valley. A time trend analysis conducted on

15 wells sampled by both the U.S. Bureau of Reclamation in 1989-90 and ADEQ in 1995 showed few significant groundwater quality parameter level differences indicating that groundwater quality has been relatively unchanged during this time period.

CONCLUSION

This regional study to assess the groundwater quality of the Yuma Groundwater Basin (YGB) was conducted by ADEQ during 1995. The study had six major objectives: obtain baseline data throughout the basin, examine groundwater quality differences between various areas, examine relationships with groundwater quality parameter levels and indices such as groundwater depth and other groundwater quality parameter levels, assess the impact on groundwater quality from specific land uses, investigate groundwater quality changes over time, and establish an ambient monitoring index well network. The results of the study indicated the following key findings for each objective:

A) Obtain baseline data on the occurrence, concentrations, and ranges of a wide-array of groundwater quality parameters:

- Piper trilinear water chemistry diagrams revealed the groundwater throughout the YGB is fairly uniform and is similar to water in the Colorado River and Gila River. Most groundwater samples collected in this study exhibited sodium-sulfate, sodium-chloride, or calcium-sulfate type water, though the chemical differences were not great as the dominant anion and cation typically contributed less than 50% to the ions in solution.

- Ten of the inorganic groundwater quality parameters sampled for have associated health-based Primary MCLs. Of these 10 parameters, only one - nitrate - was detected above the Primary MCL and/or Arizona Aquifer Water Quality Standards (AWQS) in seven groundwater samples from five wells. Elevated nitrate concentrations were only detected in four wells located in the eastern Gila Valley and one well located in the Yuma Mesa in this study.

- This study discovered elevated nitrate levels in the eastern Gila Valley within the following boundaries: the Southern Pacific Railroad tracks to the east, US Highway 95 to the north, the Wellton-Mohawk Canal/Gila Gravity Main Canal to the west, and US Highway 95 to the south. Within this area, groundwater samples often exceeded the 10.0 mg/l Primary MCL, with one sample having a nitrate (as N) concentration of 122 mg/l.

- Ten of the inorganic groundwater parameters sampled for have associated aesthetics-based Secondary MCLs. All groundwater samples collected in the YGB exceeded at least one Secondary MCL with TDS, Cl, SO_4, Fe, and Mn exceedences especally common. The results from this study indicate that although most groundwater in the YGB meets standards for use as a potable resource, with the high levels of many Secondary MCL parameters, the water may not taste very palatable and/or be a good cleaning agent. As a result, most households use their well water only for non-potable purposes.

- The presence of the banned pesticides, DBCP and EDB, was also examined in this study. These pesticides were detected in some YGB groundwater samples during the late 1970s and early 1980s. In groundwater samples collected by ADEQ from 36 wells in this study, there were no confirmed detections of either pesticide.

- The presence of currently-registered pesticides in groundwater was also a component of this study. As a result, groundwater samples were collected for GWPL analysis. This analysis consists of the 152 pesticides used in Arizona that are considered most likely to leach to the groundwater through normal agricultural use. In 21 groundwater samples collected in this study, there were no detections of any of the 152 pesticides.

- Radionuclide levels in groundwater were also examined in this study. In seven samples collected throughout the YGB, none exceeded the Primary MCLs established for either gross alpha or radium-226 and radium-228.

B) Examine various spatial areas within the YGB for statistically significant groundwater quality differences:

- The variation in groundwater quality parameter levels was assessed between the two shallowest groundwater zones in the YGB: the upper, fine-grained zone and the lower, coarse-gravel zone. The results of ANOVA analysis indicated no significant differences existed in the levels of any groundwater quality parameters between the two groundwater zones.

- The variation in groundwater quality parameter levels was assessed among three physiographic areas in the YGB: Gila Valley, Yuma Mesa, and Yuma Valley. The results of ANOVA analysis indicated many significant differences exist in the levels of groundwater quality parameters among the three physiographic areas. Parameters such as Ca, Cl, Fe, hardness, Mg, Mn, K, Na, SO_4, TDS, TKN, and turbidity were significantly higher in Gila Valley than Yuma Mesa, while B, F, Mn, and Na were significantly higher in Gila Valley than Yuma Valley. Finally,Ca, Fe, and turbidity were significantly higher in Yuma Valley than Yuma Mesa while nitrate was higher in Yuma Mesa than Yuma Valley.

- The variation in groundwater quality parameter levels was assessed among groundwater zone/physiographic areas in the YGB. The results of ANOVA analysis indicated that parameters such as Ca, hardness, Fe, Mg, Mn, nitrate, K, and TKN differed significantly between groundwater zone/physiographic areas. Many of these groundwater quality parameters were significantly higher in Gila Valley coarse-gravel than Yuma Mesa fine-grained, though other differences in groundwater zone/physiographic areas occurred.

- The variation in groundwater quality parameter levels was assessed among well types in the YGB. This was conducted as a rough method for examining for groundwater quality differences stemming from land use. Well types sampled for the study include domestic, municipal, drainage, irrigation, and industrial. The results of ANOVA analysis indicated that the

only groundwater quality parameters that differed significantly among well types were F and Mn. Tukey analysis showed that domestic, drainage, and industrial wells had levels of F significantly higher than in municipal wells.

C) Examine relationships with groundwater quality parameter levels and indices such as groundwater depth and other groundwater quality parameter levels:

- Groundwater quality parameter level variations with groundwater depth were examined using three methods: linear, exponential, and biphasic. Using analytical results from the 42 randomly sampled wells indicated that 9 of the 18 parameters examined had one or more mathematical equations significantly relating these parameter levels to groundwater depth. These parameters included total alkalinity, hardness, turbidity, Ca, nitrate, TKN, SO_4, Fe, and Mn. A pattern emerged in which the concentration of these 9 groundwater quality parameters would decrease with increasing groundwater depth below land surface (bls). Using the same methods, parameter levels within each groundwater zone and physiographic area were also examined for relationships with groundwater depth. Generally groundwater zone results were similar to the overall results, while fewer significant relationships were found within physiographic areas.

- Groundwater quality parameter levels were compared to one another using the Pearson correlation coefficient to determine their strength of association. There were many significant positive correlations using the overall analytical results, indicating that as the levels of one groundwater quality parameter vary, the levels of many other groundwater quality parameters tend to have a corresponding change in concentration. Of the 18 parameters in the matrix, hardness, Ca, Mg, TDS, SO_4, Fe, Mn, turbidity, Cl, TKN, total alkalinity, B, Na, K, and NH_3-N had significant correlations with at least 50% of the other parameters while pH, nitrate, F, and As had significant correlations with less than 50% of the other parameters. The correlations between parameter levels were typically positive (except generally for pH and nitrate), indicating that with most parameters, as the concentration of a parameter rises, other parameters tend to have a corresponding increase. Similar results occurred when the data base was divided into groundwater zones, while fewer significant groundwater quality parameter level correlations were found when using only physiographic areas.

D) By the use of targeted sampling, assess the impact on groundwater from potential contaminant sources related to specific land uses:

- Limited targeted groundwater sampling was conducted near the permitted biosolids application area (Yuma Mesa), the Cocopah Landfill (Yuma Mesa), the Yuma County Septic Advisory Area (Yuma Valley), and the City of San Luis (Yuma Mesa). Groundwater quality sampling results from targeted wells considered most likely to have impacts from these potential contaminant sources were compared with 95% Confidence Intervals developed for the area to investigate possible influences. Few parameter levels from the targeted samples exceeded the upper 95% Confidence Levels; therefore based on this approach, no groundwater quality impacts were discerned from any of these land uses.

E) To identify trends in groundwater quality:

- A time-trend analysis was conducted using groundwater quality collected by ADEQ in 1995 and the USBR in 1989-90 from the same 15 YGB wells, the majority of which are located in the lower, coarse-gravel zone. Linear regression revealed less than a 2% overall variation between 15 parameters in the two data sets while a Wilcoxon test showed only K and SO_4 had significant higher parameter levels for the 1995 ADEQ samples than the 1989-90 USBR samples. Based on data collected for these two studies, it does not appear that groundwater quality in the YGB has significantly changed during the five years between the studies.

F) Establish an ambient groundwater monitoring well network in the YGB:

- An ambient groundwater quality monitoring index well network composed of 18 wells has been established in the YGB. Similar to this study, the well selection follows a statistical design with the wells being equally divided between the two upper groundwater zones and three physiographic areas. The ambient index well network will be resampled at intervals greater than five years based on the few significant groundwater quality parameter level changes between the 1989-90 USBR study and the 1995 ADEQ study.

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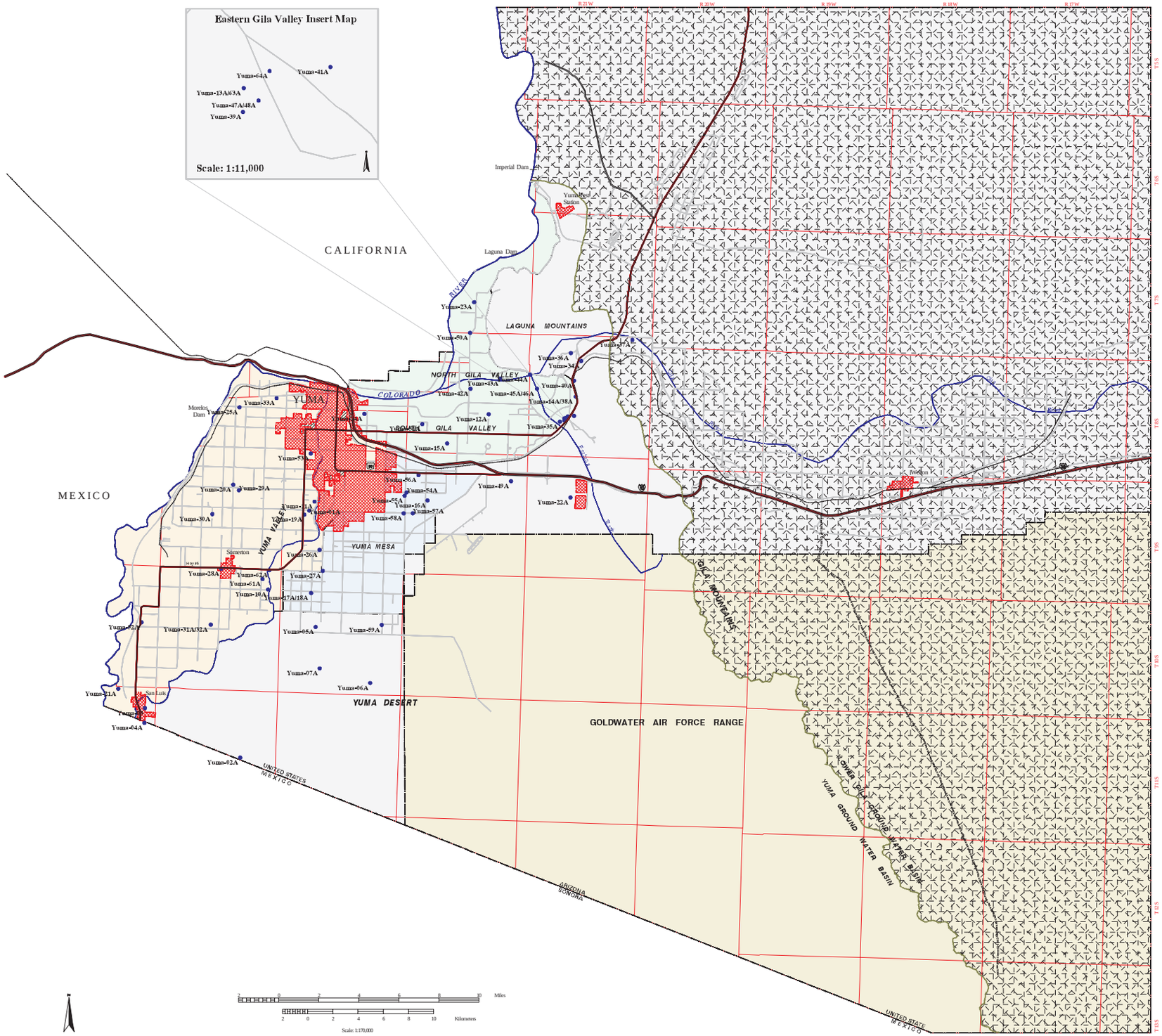
Figure 1. Location of Groundwater Samples Collected by ADEQ in the YGB



Legend

- Gila Valley
- Goldwater Air Force Range
- Yuma Mesa
- Yuma Valley
- Urban Area
- River and Wash
- Interstate Highway
- State Highway
- Rail Road
- Groundwater Sample Number